APPENDIX A

Air Quality System (AQS) and Indiana Department of Environmental Management (IDEM) Monitor Data Values for Southwestern Indiana Area (2004-2006)

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Monitoring Data for the Southwestern Indiana Area

				Annual Average	2004-2006 Average
SITE ID	**COUNTY**	**SITE NAME**	**YEAR**	**µg/m^3**	**µg/m^3**
18-037-2001	Dubois	Jasper	2004	14.42	
18-037-2001	Dubois	Jasper	2005	16.92	
18-037-2001	Dubois	Jasper	2006	13.54	**15.0**
18-163-0006	Vanderburgh	Civic Center	2004	13.23	
18-163-0006	Vanderburgh	Civic Center	2005	16.49	
18-163-0006	Vanderburgh	Civic Center	2006	13.72	**14.5**
18-163-0012	Vanderburgh	Mill Road	2004	13.46	
18-163-0012	Vanderburgh	Mill Road	2005	16.29	
18-163-0012	Vanderburgh	Mill Road	2006	14.05	**14.6**
18-163-0016	Vanderburgh	Univ of Evansville	2004	13.68	
18-163-0016	Vanderburgh	Univ of Evansville	2005	16.67	
18-163-0016	Vanderburgh	Univ of Evansville	2006	14.15	**14.8**

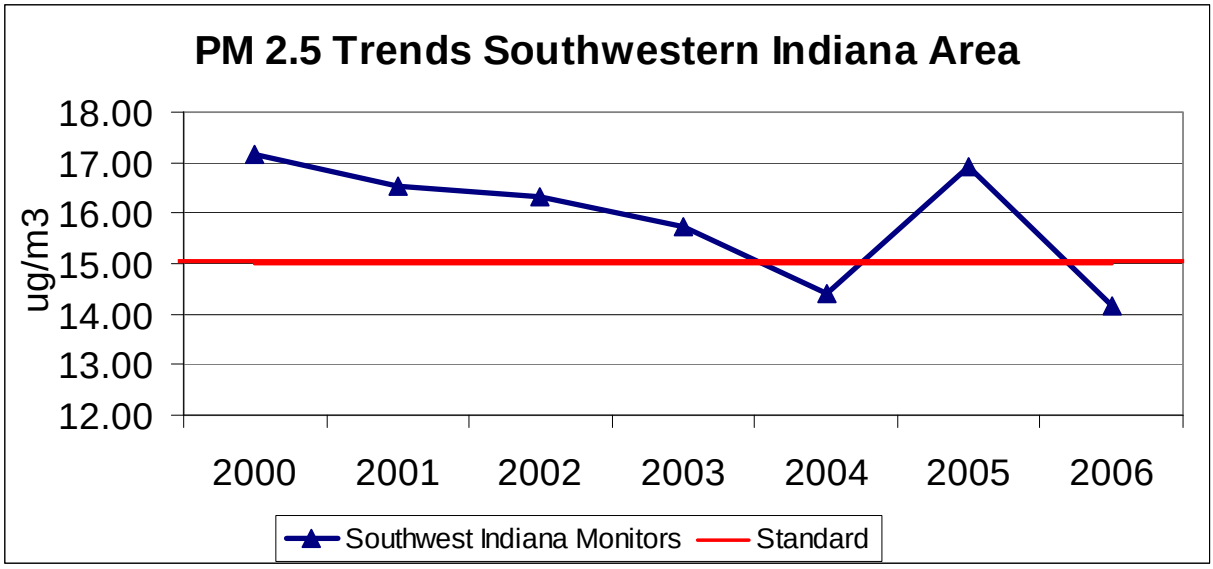
		Yearly Annual Means						
City	**Site Name**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Jasper	200 W 6th St	17.16	16.54	16.34	15.72	14.42	16.92	13.54
Evansville	Civic Center	16.17	15.45	15.36	14.93	13.23	16.49	13.72
Evansville	W Mill Rd	16.17	15.15	15.27	15.27	13.46	16.29	14.05
Evansville	Univ of Evansville	15.70	16.16	15.24	15.09	13.68	16.67	14.15

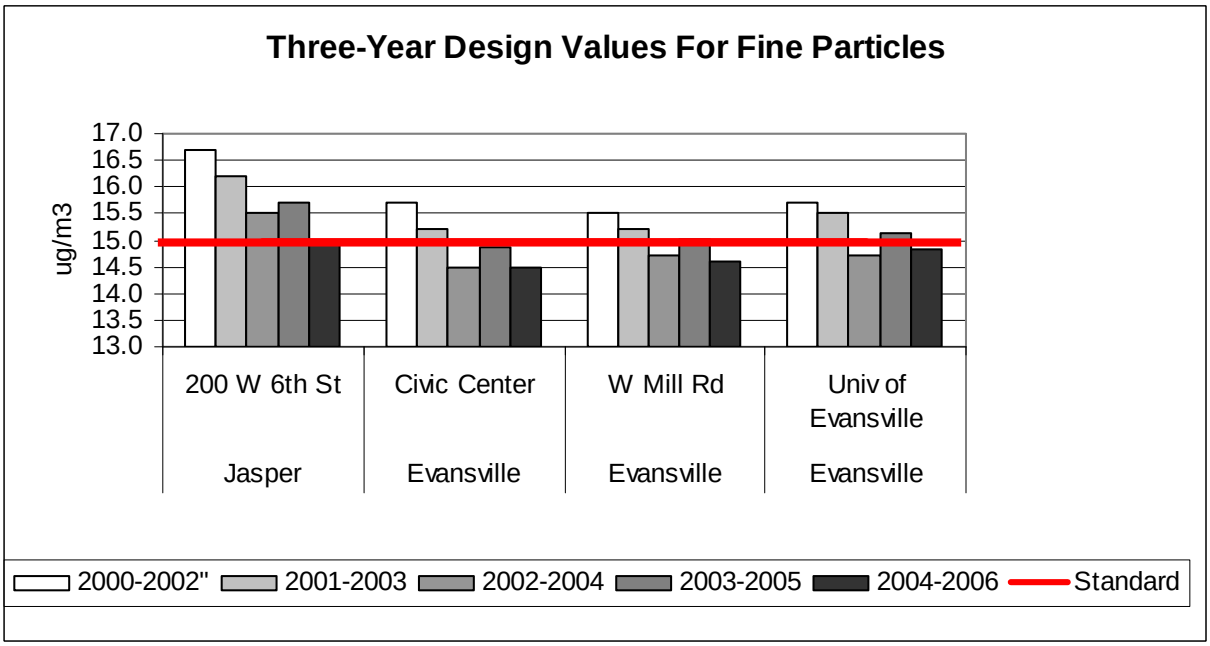
value above the standard

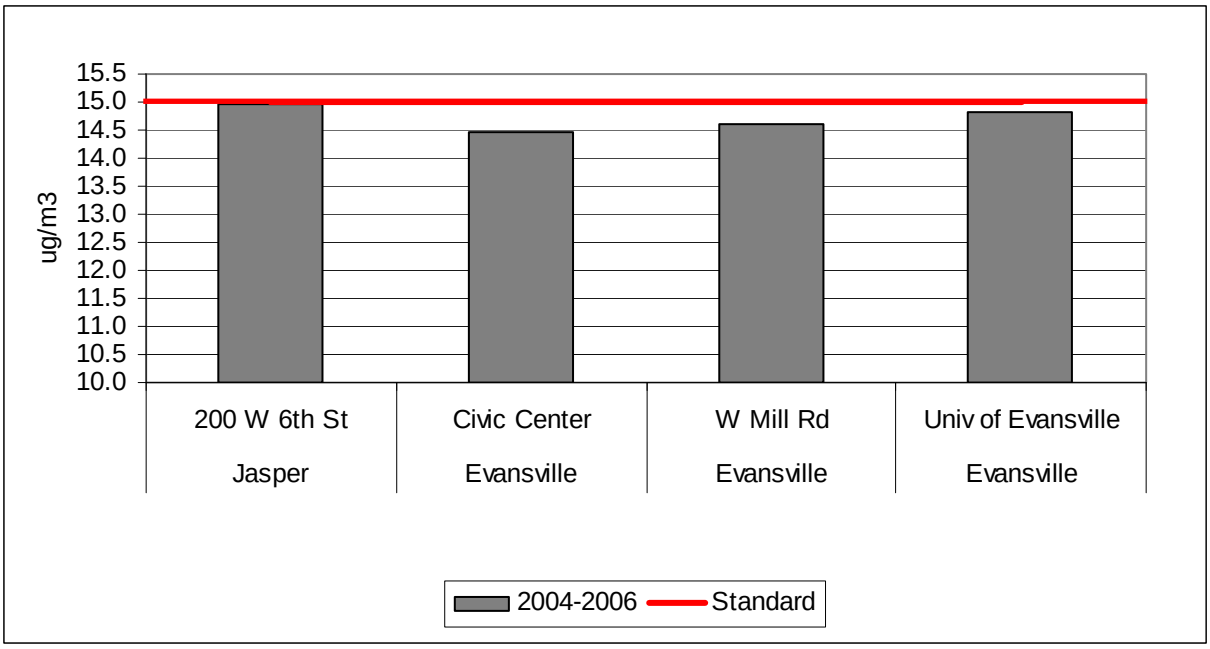
			Three Year Design Values				
Site #	**City**	**Site Name**	**00-02**	**01-03**	**02-04**	**03-05**	**04-06**
18-037-2001	Jasper	200 W 6th St	16.7	16.2	15.5	15.7	15.0
18-163-0006	Evansville	Civic Center	15.7	15.2	14.5	14.9	14.5
18-163-0012	Evansville	W Mill Rd	15.5	15.2	14.7	15.0	14.6
18-163-0016	Evansville	Univ of Evansville	15.7	15.5	14.7	15.1	14.8

value above the standard

incomplete data


PM 2.5 Trends Southwestern Indiana Area
18.00
17.00
16.00
15.00
14.00
13.00
12.00
ug/m3
2000
2001
2002
2003
2004
2005
2006
Southwest Indiana Monitors
Standard


Three-Year Design Values For Fine Particles
17.0
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
ug/m3
200 W 6th St
Jasper
Civic Center
Evansville
W Mill Rd
Evansville
Univ of Evansville
Evansville
2000-2002"
2001-2003
2002-2004
2003-2005
2004-2006
Standard


15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
ug/m3
200 W 6th St
Jasper
Civic Center
Evansville
W Mill Rd
Evansville
Univ of Evansville
Evansville
2004-2006
Standard

APPENDIX B

Air Quality System (AQS) and Indiana Department of Environmental Management (IDEM) Monitor Data Values for Southwestern Indiana Area (2005-2007)

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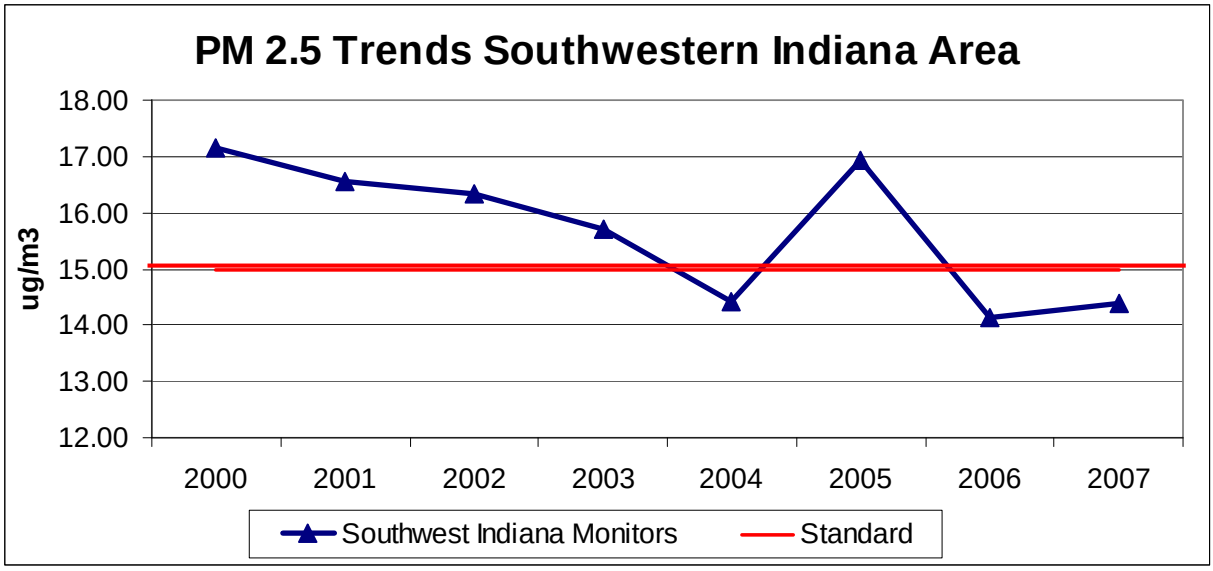
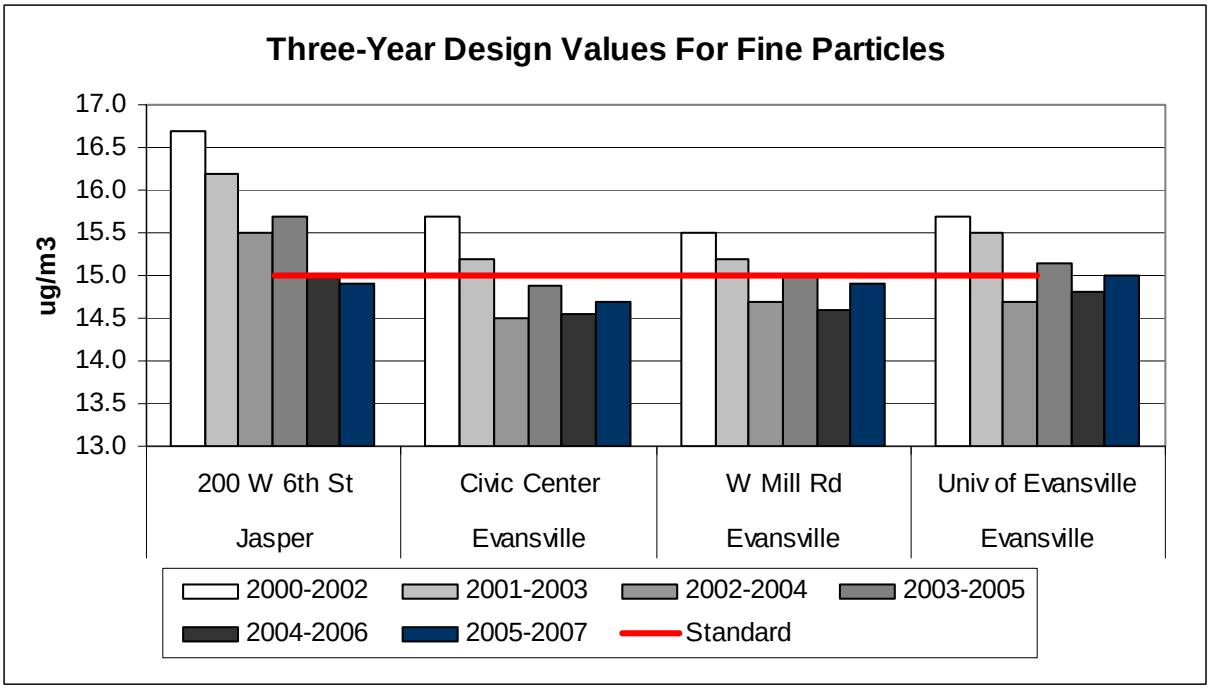
Monitoring Data for the Southwestern Indiana Area

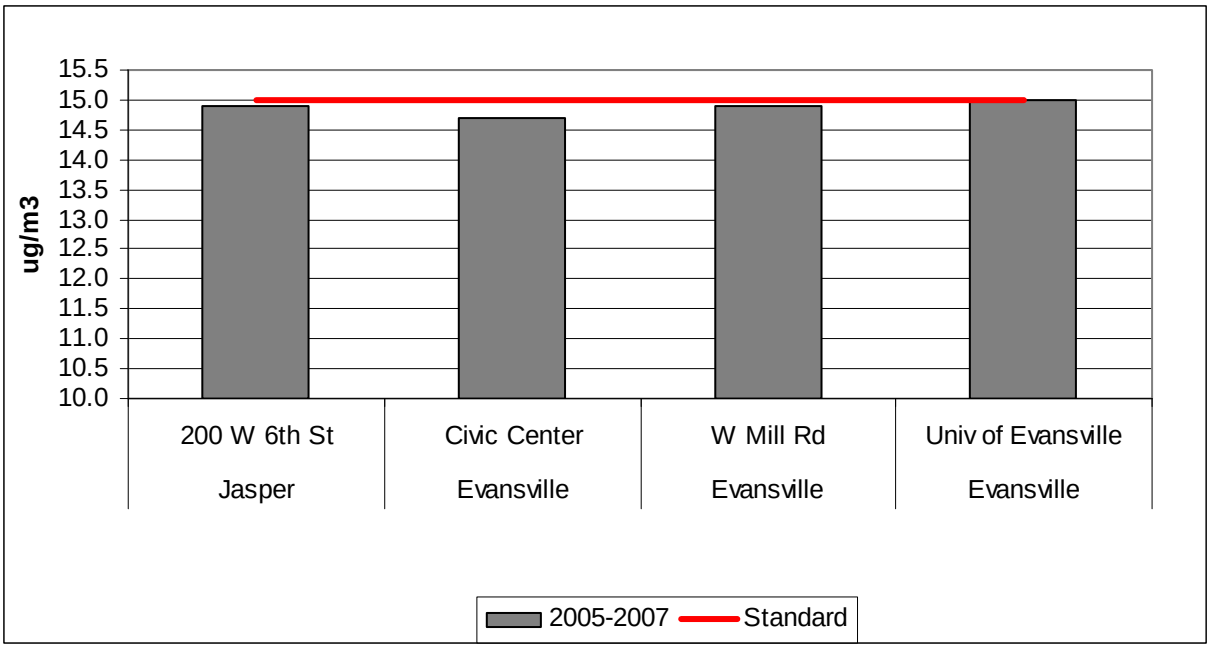
				Annual Average	2005-2007 Average
SITE ID	**COUNTY**	**SITE NAME**	**YEAR**	**µg/m^3**	**µg/m^3**
18-037-2001	Dubois	Jasper	2005	16.92	
18-037-2001	Dubois	Jasper	2006	13.54	
18-037-2001	Dubois	Jasper	2007	14.39	**14.9**
18-163-0006	Vanderburgh	Civic Center	2005	16.49	
18-163-0006	Vanderburgh	Civic Center	2006	13.72	
18-163-0006	Vanderburgh	Civic Center	2007	13.91	**14.7**
18-163-0012	Vanderburgh	Mill Road	2005	16.29	
18-163-0012	Vanderburgh	Mill Road	2006	14.05	
18-163-0012	Vanderburgh	Mill Road	2007	14.23	**14.9**
18-163-0016	Vanderburgh	Univ of Evansville	2005	16.67	
18-163-0016	Vanderburgh	Univ of Evansville	2006	14.15	
18-163-0016	Vanderburgh	Univ of Evansville	2007	14.21	**15.0**

		Yearly Annual Means							
City	**Site Name**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Jasper	200 W 6th St	17.16	16.54	16.34	15.72	14.42	16.92	13.54	14.39
Evansville	Civic Center	16.17	15.45	15.36	14.93	13.23	16.49	13.72	13.91
Evansville	W Mill Rd	16.17	15.15	15.27	15.27	13.46	16.29	14.05	14.23
Evansville	Univ of Evansville	15.70	16.16	15.24	15.09	13.68	16.67	14.15	14.21
		value above the standard							

			Three Year Design Values					
Site #	**City**	**Site Name**	**00-02**	**01-03**	**02-04**	**03-05**	**04-06**	**05-07**
18-037-2001	Jasper	200 W 6th St	16.7	16.2	15.5	15.7	15.0	14.9
18-163-0006	Evansville	Civic Center	15.7	15.2	14.5	14.9	14.5	14.7
18-163-0012	Evansville	W Mill Rd	15.5	15.2	14.7	15.0	14.6	14.9
18-163-0016	Evansville	Univ of Evansville	15.7	15.5	14.7	15.1	14.8	15.0
			value above the standard					
			incomplete data					


PM 2.5 Trends Southwestern Indiana Area
ug/m3
18.00
17.00
16.00
15.00
14.00
13.00
12.00
2000
2001
2002
2003
2004
2005
2006
2007
Southwest Indiana Monitors
Standard


Three-Year Design Values For Fine Particles
ug/m3
17.0
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
200 W 6th St
Jasper
Civic Center
Evansville
W Mill Rd
Evansville
Univ of Evansville
Evansville
2000-2002
2001-2003
2002-2004
2003-2005
2004-2006
2005-2007
Standard


15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
ug/m3
200 W 6th St
Jasper
Civic Center
Evansville
W Mill Rd
Evansville
Univ of Evansville
Evansville
2005-2007
Standard

APPENDIX C

Data Analysis for Missing $PM_{2.5}$ Data at the University of Evansville Monitor in Vanderburgh County, Indiana

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Data Analysis for Missing $PM_{2.5}$ Data at the University of Evansville Monitor in Vanderburgh County, Indiana

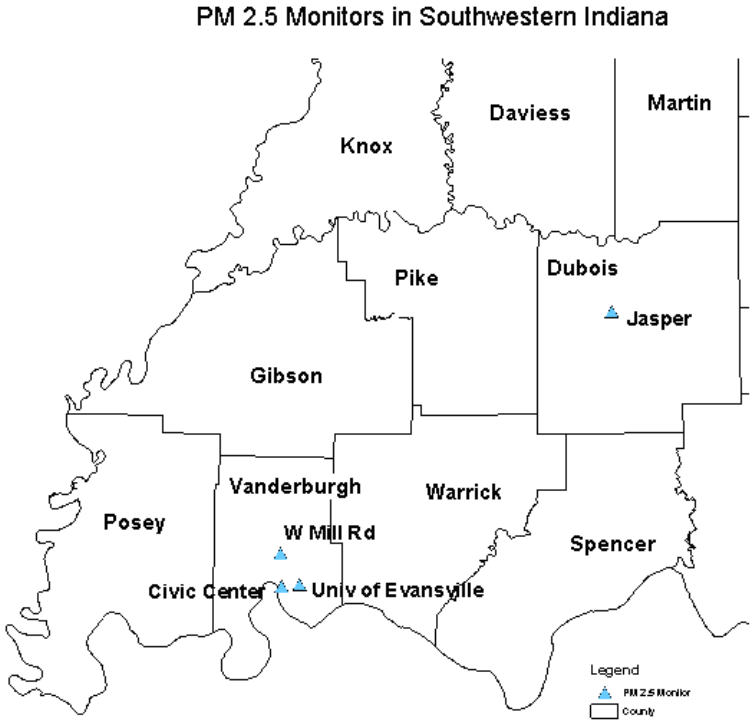
Introduction

During the second quarter of 2005 the University of Evansville (UE) monitor located in Vanderburgh County, Indiana, Site ID 18-163-0016, recorded an overall Valid Data Return (VDR) for $PM_{2.5}$ of 68%. According to U.S. EPA guidance, the monitoring data for the University of Evansville monitor located in Vanderburgh County, Indiana is incomplete. The U.S. EPA required VDR is 75%. Therefore, an analysis of missing data during the second quarter of 2005 was conducted and this section details the scenarios for filling in the missing data.

Monitoring Network

There are three $PM_{2.5}$ monitors in Vanderburgh County Indiana. These sites are: Civic Center (18-163-0006), W Mill Road (18-163-0012) and University of Evansville (18-163-0016), all located in Evansville. Indiana operates an extensive network of $PM_{2.5}$ monitors stretching throughout the state, including a monitor in nearby Dubois County in southwestern Indiana. A map showing the locations of the monitors in Southwest Indiana is below in Figure 1.

Figure 1



Calculation of the $PM_{2.5}$ Annual Standard

The U.S. EPA developed a "Guideline for Data Handling Conventions for the PM NAAQS", released in April 1999, to assess compliance with the standard. The annual $PM_{2.5}$ standard is set at 15.0 micrograms per cubic meter ($\mu g/m^3$). The annual standard is met when the 3-year average of the annual mean concentrations across a designated area is less than or equal to 15.0 $\mu g/m^3$ (micrograms per cubic meter). Any design value above this is a violation of the standard.

Missing Data Review

Examining the second quarter of 2005 for the UE monitor, the missing data was a result of a variety of problems including power failure, machine malfunction, collection errors, and the sample time out of limits. For the remaining quarters of 2005 the UE monitor had an overall valid VDR over 75% and specifically was 100% for the first quarter; 100% for the third quarter; and 97% for the fourth quarter. The dates in the second quarter of 2005 that data was missing at the monitor are April 22, May 25, 28 and 31st and June 3, 6, 9, 12, 15 and 27th.

According to U.S. EPA guidance, the 2004-2006 design value for the UE monitor site is incomplete. Table 1 below lists the annual means and three-year design value for the monitors in southwestern Indiana. All of the monitors in southwestern Indiana are below the $PM_{2.5}$ standard.

Table 1

County	Monitor Location	Annual Mean 2004	Annual Mean 2005	Annual Mean 2006	Design Value 2004-2006
Dubois	Jasper-Post Office	14.42	16.92	13.54	15.0
Vanderburgh	Evansville-Civic Center	13.23	16.49	13.72	14.5
Vanderburgh	Evansville-W Mill Rd	13.46	16.29	14.05	14.6
Vanderburgh	Evansville-Univ of Evansville	13.68	16.67	14.15	14.8*

*The University of Evansville monitor data is incomplete; it is missing the required amount of data in the second quarter of 2005.

IDEM conducted an analysis of the missing data during the second quarter of 2005 and Table 2 below provides a summary of the captured data for 2005 along with alternate methods for evaluating and substituting for the missing data.

Table 2

UNIVERSITY OF EVANSVILLE MONITOR (181630016)

	% VALID	Average A	Average B	Average C	Average D
1Q 2004	90%	13.2321429			
2Q 2004	100%	12.7			
3Q 2004	97%	16.4133333			
4Q 2004	100%	12.38			
Year 2004 Average		**13.6813691**	**13.6813691**	**13.6813691**	**13.6813691**
1Q 2005	100%	15.1833333	15.1833333	15.1833333	15.1833333
2Q 2005	**68%**	**17.0571429**	**24.2645161**	**21.7483871**	**16.17419**
3Q 2005	100%	20.6233333	20.6233333	20.6233333	20.6233333
4Q 2005	97%	13.8266667	13.8266667	13.8266667	13.8266667
Year 2005 Average		**16.6726191**	**18.4744624**	**17.8454301**	**16.4518808**
1Q 2006	97%	11.9448276			
2Q 2006	100%	14.5533333			
3Q 2006	94%	18.7551724			
4Q 2006	100%	11.3516129			
Year 2006 Average		**14.1512366**	**14.1512366**	**14.1512366**	**14.1512366**
3 Year Average (2004-2006)		**14.8350749**	**15.4356893**	**15.2260119**	**14.7614955**

Average A: Average based on no substitution. Using this average makes the data incomplete since the required VDR is 75% and the 2nd Quarter 2005 VDR is only 68%.

Average B: Average based on substituting historic high value for any day that had missing data in the 2nd Quarter of 2005. The historic high value of 39.4 is the highest value that occurred in the 2nd Quarter on June 12, 2001.

Average C: Average based on substituting highest value that occurred in the 2nd Quarter of the years 2004-2006 for any day that had missing data in the 2nd Quarter of 2005. The highest value in the 2nd Quarter for the years 2004-2006 of 31.6 occurred in the 2nd Quarter of the year 2005 on June 30.

Average D: Average based on substituting fine particulate matter values from nearby monitors. The higher of the two numbers at the Evansville Civic Center or Evansville Mill Road monitor were substituted for each day that had missing data in the 2nd Quarter of 2005.

Substituting for Missing Data (Averages B and C)

The substitution procedure for data below the required 75% VDR is a conservative mechanism to ascertain the likelihood that a site would meet or not meet the standards if the site had collected the 75% criteria. The incomplete design value identified as Average A (14.8 $\mu g/m^3$) is more indicative of the monitor's air shed than the artificial recalculated design values explained below.

Average A: Three-year average based on no substitution, calculated according to U.S. EPA guidance. Using this average makes the data incomplete since the required VDR is 75% and the 2nd Quarter VDR for the year 2005 is only 68%. U.S. EPA states that the incomplete design value of 14.8 $\mu g/m^3$, is still identified as the monitors true design value.

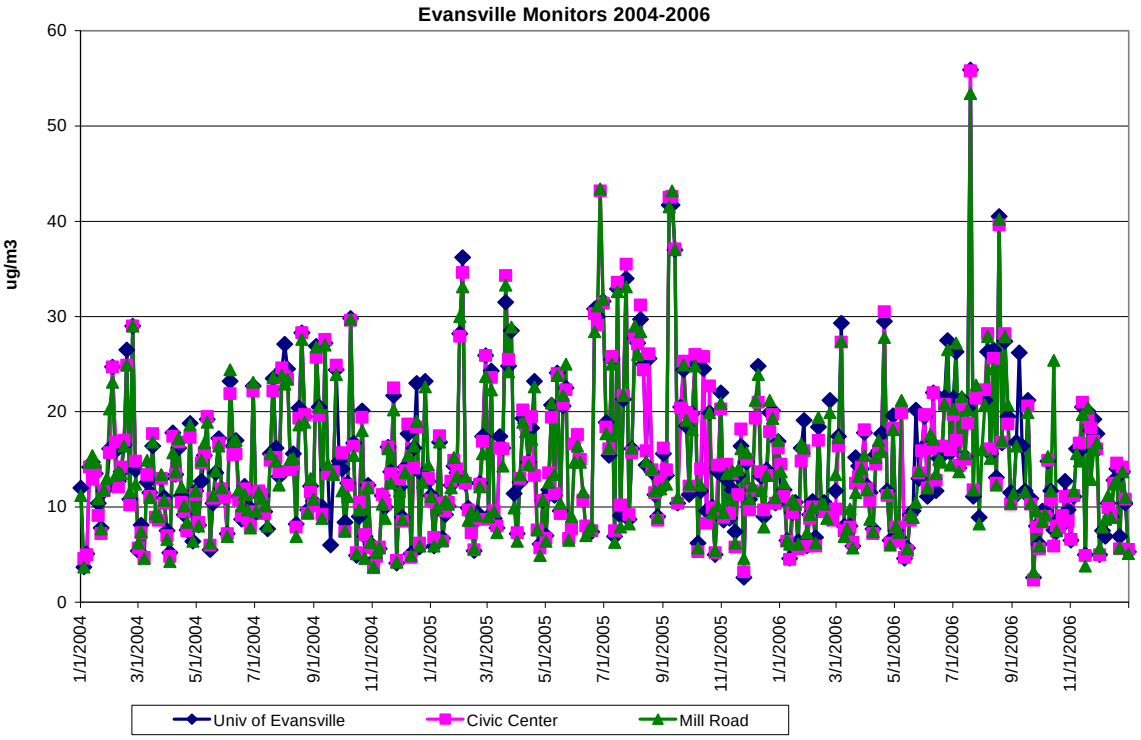
Average B: Three-year average based on substitution, calculated according to U.S. EPA guidance. The historic high value was substituted for any day that had missing data in the 2nd Quarter of 2005. The historic high value of 39.4 $\mu g/m^3$ is the highest value that occurred in the 2nd Quarter on June 12, 2001. Using this average provides a conservative number by using the highest value ever recorded in that quarter; however it makes the three-year average over the standard.

Average C: Three-year average based on substitution. The highest value that occurred in the 2nd Quarter of the years 2004-2006 was substituted for any day that had missing data in the 2nd Quarter of 2005. The highest value in the 2nd Quarter for the years 2004-2006 of 31.6 $\mu g/m^3$ occurred on June 30, 2005. Using this average provides more current data than Average B by using the 2nd Quarter high from the 3-year design period. It is IDEM's understanding that U.S. EPA is starting to use this calculation rather than Average B above. In this case, however it is not as conservative as Average B, although the three-year average remains over the standard.

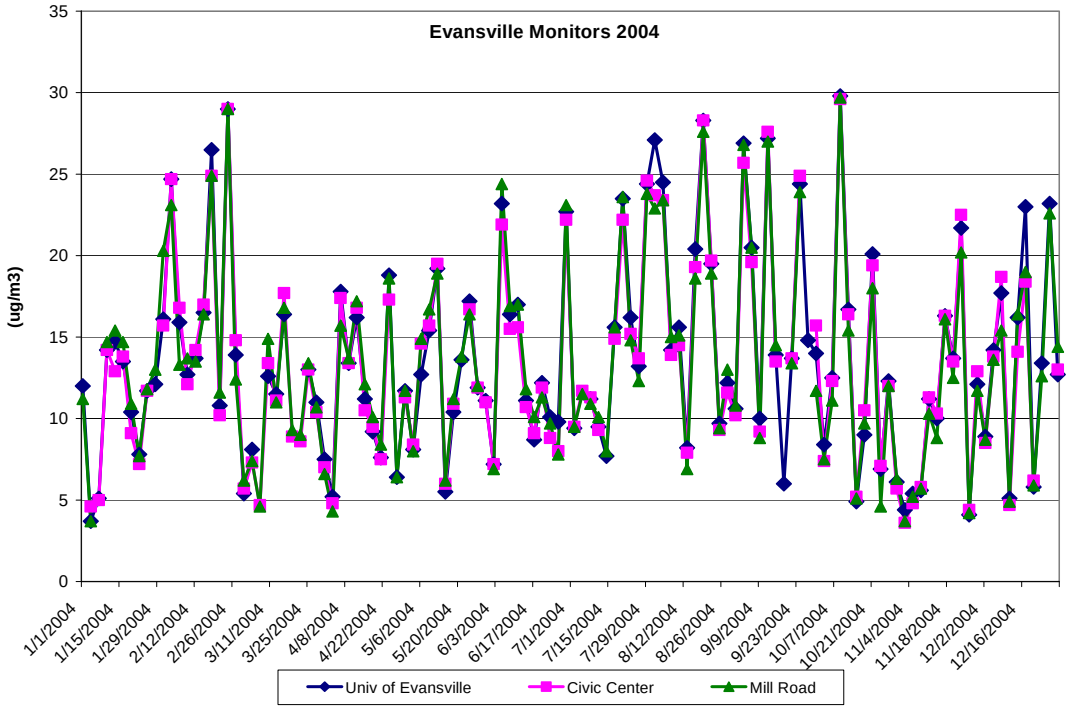
Time Series

$PM_{2.5}$ values for the years 2004-2006 at all three Evansville monitors were plotted to show comparison over time and to see how closely the monitors tracked together. The Civic Center monitor is only 1.92 miles from the University of Evansville monitor and the Mill Road monitor is only 3.84 miles away. Given the fact that the monitors are in close proximity to each other the three Evansville monitors track together very well. As illustrated in Graph 1 below, the $PM_{2.5}$ values from monitor to monitor do not show much variation and the relative differences among the sites are similar. That is, when one monitor value is high, the other monitor values are high and vice versa. Graphs 2-4 show the years 2004, 2005 and 2006 individually and Graph 5 shows the second quarter of 2005 only.

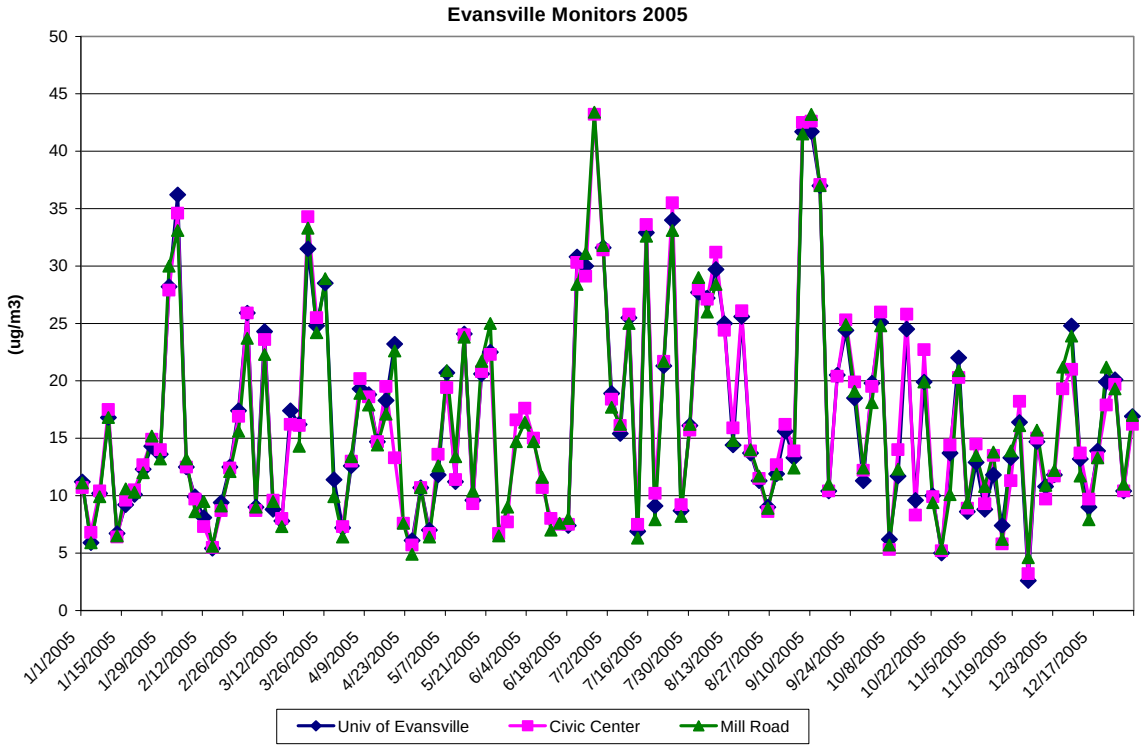
Graph 1



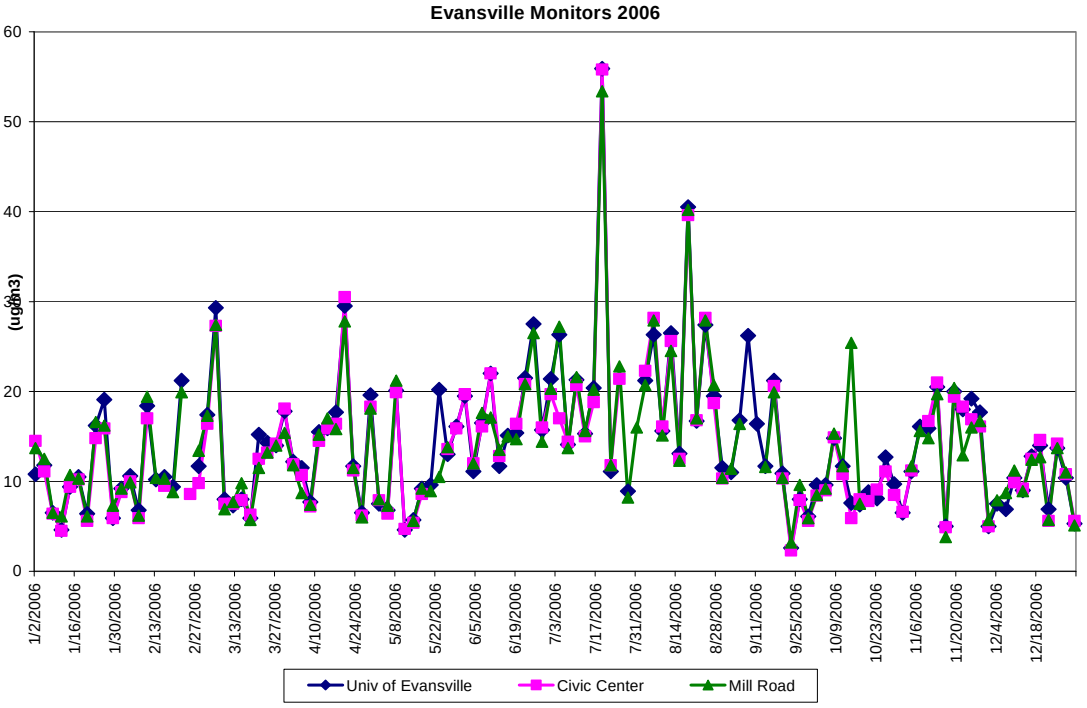
Graph 2



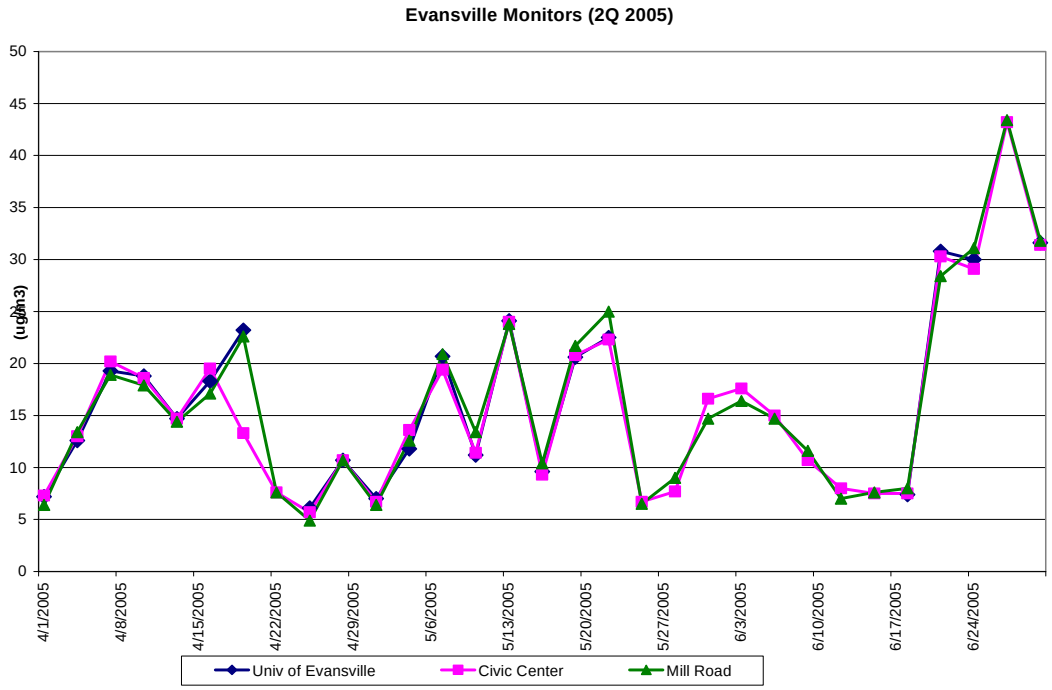
Graph 3



Graph 4



Graph 5



Correlation

Correlation is a measure of the statistical relationship between two comparable time series. In this case, the University of Evansville monitor was compared to the Civic Center monitor and to the Mill Road monitor. The relationship stated as the correlation coefficient reflects the simultaneous change in value of the pairs of numerical values over time. The correlation coefficient, which lies between the range of -1.00 to +1.00, as a positive or negative probability that the members of a pair relate to each other. A negative reading suggests that one member of the pair consistently moves up while the other moves down. Conversely a positive reading suggests there is a tendency for the pair to move together in the same direction.

The correlation coefficient was calculated between the three Evansville monitors for the years 2004-2006. The correlation coefficient between the University of Evansville monitor and the Civic Center monitor is 0.987469. The correlation coefficient between the University of Evansville monitor and the Mill Road monitor is 0.976652. Both of the correlation coefficients are positive numbers very close to 1.00 proving that the Evansville monitors track very close together.

Additionally, the average for each of the sites for the 21 days in which all monitors operated during the second quarter of 2005 were calculated. These averages came to 17.1 $\mu g/m^3$ at UE, 16.6 $\mu g/m^3$ at Civic Center, and 17.1 $\mu g/m^3$ at Mill Road. This further illustrates the correlation between the sites.

Day-Specific Substitution (Average D)

Average D: Three-year average based on substitution. Fine particulate matter values from the nearby Evansville Civic Center and Evansville Mill Road monitors were substituted for the missing days at the University of Evansville monitor. The higher of the two values at the Civic Center or Mill Road monitor was substituted for each day that had missing data in the 2nd Quarter of 2005. Using this average provides an average very close to the true design value identified in Average A.

Table 3 below lists the daily values for each of the three Evansville monitors for the 2nd Quarter of 2005. The highlighted values for the Civic Center and Mill Road monitors show which value for that day was used for substitution for the missing data at the University of Evansville monitor.

Table 3

Second Quarter 2005 Values			
	Univ of Evansville	Civic Center	Mill Road
4/1/2005	7.2	7.3	6.4
4/4/2005	12.6	13.0	13.4
4/7/2005	19.3	20.2	18.9
4/10/2005	18.8	18.6	17.9
4/13/2005	14.7	14.7	14.4
4/16/2005	18.3	19.5	17.1
4/19/2005	23.2	13.3	22.6
4/22/2005		7.6	7.6
4/25/2005	6.1	5.7	4.9
4/28/2005	10.7	10.7	10.7
5/1/2005	7.0	6.7	6.4
5/4/2005	11.8	13.6	12.6
5/7/2005	20.7	19.4	20.9
5/10/2005	11.2	11.4	13.4
5/13/2005	24.1	24.0	23.8
5/16/2005	9.6	9.3	10.4
5/19/2005	20.6	20.8	21.7
5/22/2005	22.5	22.3	25.0
5/25/2005		6.7	6.5
5/28/2005		7.7	9.0
5/31/2005		16.6	14.7
6/3/2005		17.6	16.4
6/6/2005		15.0	14.7
6/9/2005		10.7	11.6
6/12/2005		8.0	7.0
6/15/2005		7.5	7.6
6/18/2005	7.4	7.5	8.0
6/21/2005	30.8	30.3	28.4
6/24/2005	30.0	29.1	31.1
6/27/2005		43.2	43.4
6/30/2005	31.6	31.4	31.8

Conclusions

The 2004-2006 $PM_{2.5}$ three-year average of 14.8 µg/m^3 for the University of Evansville monitor is incomplete; it is missing the required amount of data in the second quarter of 2005. According the the *Guideline on Data Handling Conventions for the PM NAAQS*, issued April 1999, U.S. EPA states that the incomplete design value of 14.8 µg/m^3, is still identified as the monitor's true design value.

U.S. EPA guidance recommends substituting the quarterly maximum value (Average B which is the worst-case scenario) which results in the value being above the standard. However, IDEM does not believe that the substitutions in scenarios B or C necessarily result in a value representative of the $PM_{2.5}$ concentrations registered at the University of Evansville monitor. Since the Evansville monitors have such a high correlation and track well together we think Average D, using the day-specific substitution, best represents the true value for the University of Evansville monitor had it collected the required 75 % VDR.

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